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ABSTRACT

This paper contains a report on two science education methods courses for the teaching of biology developed at Arizona State University at Tempa. One course is for preservice teachers only and is taught each fall semester, as it has been since 1964, by a team consisting of a high school biology teacher, a science consultant for the Phoenix school district, and an Arizona state faculty member. As part of the course experiences, students concentrate on inquiry-oriented laboratory investigations using living organisms where possible, class discussions, films, BSCS single topic inquiry filmstrips, and other related activities. One of the major objectives is to permit students to become familiar with methods, techniques, and use of biological materials. In the spring semester, another course using the inquiry field study approach involves inexperienced but certified biology teachers qualifying for admission to a degree program leading to a Master of Science in Biology. These participants in the Prospective Teacher Fellowship Program plan and conduct a two-week resident field study program for 60 high school biology students (30 high school students per week). Also reported are details of an Environmental Education Teach-In involving the states of Hawaii, California, Nevada and Arizona. (PEB)

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EDUCATION THROUGH INQUIRY - AN EXPERIMENTAL ASPECT OF TEACHER PREPARATION AT ARIZONA STATE UNIVERSITY

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Arizona State University has been training teachers since 1886. First as the Territorial Normal School at Tempe, Arizona, later as Arizona State Teacher's College, then as Arizona State College, and finally as Arizona State University so designated by vote of the people of the State in 1958.

During this period, the School experienced a growth spurt from 553 students in 1945 to 11,128 students in 1960, believed to be a modern American record of its kind. Presently, the enrollment at Arizona State University stands at 26,564 students. Of this total, nearly 3,000 are enrolled in the College of Education. The University averages approximately 1,800 student teachers per year. On the basis of the number of earned degrees awarded in Education for 1970, Arizona State University ranked in the top six of the major accredited schools in the nation.

One other bit of information may help to set the stage for this report. The majority of prospective teachers at Arizona State University receive their professional education course work, degree, and teaching certificate through the College of Education. However, at the secondary level the special methods courses are taught by the subject matter departments within the various Colleges, and student teaching experiences are supervised by faculty from the subject matter departments. Thus, the course, Methods of Teaching Biology, is the joint responsibility of the departments of Botany and Zoology whose course offerings provide an undergraduate teaching major in the biological sciences.

Since 1964 the Biology Methods class has been team-taught during each Fall Semester. For the past five years, the teaching team has consisted of Mr. Leon Jordan, biology teacher at Camelback High School, Mr. Norbert J. Konzal, science consultant for the Phoenix Union High School District, and Dr. Kenneth V. Pike, the Arizona State University faculty member responsible for the course.

The course experiences for students concentrate on: inquiry oriented laboratory investigations using living organisms where possible; the use of class discussions; films; BSCS single topic inquiry filmstrips; and other activities relating to the teaching of biology. The effort is to provide a high degree of involvement which will permit students to become familiar with the methods, techniques and use of biological materials recommended for present day biology programs.

A continuing evaluation of the course and student experiences has caused the instructors to question and change certain course procedures. For example, our analysis of the classroom-laboratory situation for its inquiry potential raised some interesting doubts. How could we justify some of the pseudo-inquiry activities such as film viewing as a true inquiry experience? Often the film was misleading and did not present the true nature of the material, substance, organism, or event to which attention was being directed. As a result of this dissatisfaction with the classroom approach to inquiry, we turned to field studies in an effort to involve prospective teachers in true inquiry experiences using the environment as the primary source.

Our approach was to take 12 - 16 A.S.U. students on a Saturday field trip. The procedures used during the field trip were designed to raise questions rather than to give preconceived answers. The purpose of the trip was to involve prospective teachers in an inquiry process by providing each student an opportunity to identify and develop a field inquiry using the rest of the group as his class. Instructors would demonstrate

the process and then provide students an hour to explore the environment in order to identify an inquiry topic he would like to develop with the class.

It was obvious that the majority of students had never experienced this type of field trip. Trips in connection with other courses had been taken for purposes of collecting specimens or instructors had used the field trip as an opportunity to lecture about the phenomena observed. The technique of developing an inquiry from careful observations and proposing hypotheses based on observed evidence was a new approach for most.

After a period of training in use of the inquiry approach on peers, a second one day trip was organized to the same site for sixty high school biology students. Each Arizona State University student worked with a group of 4 or 5 high school biology students.

As we have attempted to describe and define the essence of a field inquiry, we have developed a simple outline that seems to provide direction for the teacher.

1. First identify the "problem".

   Here it is essential that all members of the group understand the question, problem, or "discrepant event" under consideration. Often the question or problem has to be re-stated before it truly defines the inquiry to be considered.

2. How might we explain or account for the phenonmenon under consideration?
   a.
   b.
   c.

   It is important here to solicit at least two or three possible hypotheses lest we leave students with the impression the one idea put forth must be the correct answer and therefore no further investigation or thought is necessary.

4. What evidence is available to support one or another of our hypotheses?

5. What additional evidence do we need in order to decide which are the most likely explanations?

6. Which of the hypotheses can be tested by controlled investigation?

7. Design the investigation(s). What instruments and equipment will be needed to collect pertinent data?

8. Where should the investigation(s) be conducted? In the field? or back in the laboratory?

9. If in the field, how should we proceed?

10. If back at the school, what information do we need to gather in the field in order to set up a controlled investigation in the laboratory?

The following list is typical of the inquiries encountered and developed in the field:

1. How can we account for the cylinder like protuberances on the backs of smaller giant water bugs?

2. How does the environment affect the growth and development of a cholla cactus?

3. Do grasshoppers change their color?

4. How can we account for the presence of damsel flies of three different colors; red, blue, and brown in the same general area near a stream?

5. Does the depth of a stream affect the life found there?

6. Why were so many large rhinocerus beetles found dead in sandy areas close to the stream?

7. Does growing fungus have an effect on a tree?

8. Why does the water in an isolated pool contain more life than a stream section of continuously flowing water?

9. Why did we always find planaria (flatworms) under rocks?

10. What are the ball shaped orange or brown growths found on scrub oak leaves?

11. How can we account for the presence of cactus plants which are adapted to growing under desert conditions also growing in higher cooler conditions found in chaparral vegetative cover?

12. Why are ferns found in one area and not in another?

The problems developed exhibit varying degrees of open-endedness with regard to the extent of student participation versus teacher direction. The following sample reported by Miss Sally Ann Walker, as A.S.U. student teacher, may serve to clarify the techniques employed.

The Ant Trail - An Inquiry

A provocative and exhilerating inquiry can be made in the field by simply ovserving the normal behavior of the ant. We made just such an inquiry a few weeks ago on a field trip.

One student discovered, in a sparsely vegetated area, a trail of ants approximately a yard long. The ants were moving from one central area in a very narrow line (about one-eighth of an inch) to another area where there appeared to be some food. There were ants moving in both directions. It was an interesting sight, and the students were excited to discover why the ants moved the way they do.

The discussion began immediately and many questions were asked:

1. Could the ants find the food without following the others?
2. Was there actually something being laid down on the trail to cause a response?

3. How did the first ant find the food?
4. Were the ants smelling the food?
5. Were the ants laying down a trail by themselves (without the food)?
6. If the trail is broken, what will happen?
7. What will happen if we place food on the other side of the ants home?

There were several explanations given by the students as they continued their discussion:

1. The ants were following the scent of the food.
2. The ants were making a trail with the food as they carried it back to their home.
3. Each ant was following the ant in front of him.
4. The ants were making a trail with their feet.
5. The ants produce a scent that could easily be followed.

Thus there were many areas to explore and experiment with in order to find possible solutions.

We began experimenting by rubbing across the trail with a handkerchief in an area about an inch long. The ants began running around in circles and generally not moving forward. The trail had been stopped in both directions. In a few minutes, however, one ant ventured across and was soon followed by a few more and a few more until finally the trail was as it was before. How amazing !

Next we took a bit of the food and rubbed it along the ground from the den to a spot about three feet out; thus making a trail with the scent of the food. After several minutes nothing had happened.

Finally, we placed a bit of food away from the den and the other trail. We then observed many minutes later, an ant at the food. It returned to the den. Soon, however, two more ants came and then several more, and within a short time another trail was in existance. What an interesting phenonmenon!

Many students concluded that the ants produced a scent which the other ants could smell. Other students were not sure. But the possible explanations had been narrowed down. The students were still interested.

In the classroom I will begin a study and investigation of pheromones (substances secreted by exocrine glands and released into the external environment).

A second phase of the program deals with a special course which is offered each spring semester to selected secondary education biology majors desiring extended training in this inquiry field study approach. The special course was developed in connection with a U.S. Office of Education grant awarded Arizona State University in 1966 under the Higher Education Act, 1965, for a Prospective Teacher Fellowship Program. This program was designed for inexperienced teachers who had received the proper secondary certification to teach biology and who otherwise qualified for regular admission into the degree program leading to a Master of Science in Biology.

One of the innovative aspects of the degree program was a special course, Field Ecology, designed to provide field teaching experiences for Fellows, instructing biology students from local high schools in the Phoenix Union High School District.

After three semesters of graduate study and several weeks of specialized training in conducting field studies in ecology, the Fellows planned and conducted a two week resident field study program for sixty high school biology students from the Phoenix Union High School District. Thirty students were transported by bus each of the two weeks to the Arizona State University Environmental Education Center at Camp Tontozona for a five day field study program under the supervision of the participating Fellows. A certificated teacher from the Phoenix District also attended as the legal representative of the District. The high school students paid a $20.00 fee which covered food and lodging expenses of the trip.

Upon completion of the two week experience, high school students, teachers, and parents were given an opportunity to evaluate the program according to any scientific or social gains observable.

The following comments are typical high school student reactions:

" I thought the program was a complete success."

" The camp program is an extremely good idea. I learned more in one week of study up in Camp Tontozona than I could learn in a month in a classroom."

" In my opinion this program was beneficial in all ways - you learned how to observe nature more clearly and how to live in a different and unusual surrounding with new people."

" I feel that I gained something from everything we did. Some of the things I learned and abilities I began to use, such as observation, may not deal only with biology but with everything I study."

" I believe that in all ways it benefited me because I didn't have that strong of an interest in biology but the trip changed my attitude and helped me to understand biology better."

While it is true the cited comments lack the research support of statistical significance, can anyone doubt that these comments were sincere efforts to describe a reaction to an experience that had personal significance for the student involved?

In answer to selected questions students responded as follows:

Did this program improve your understanding of biology by causing you to observe more accurately? ..... 100% answered Yes.

Did this program improve your understanding of biology by developing your appreciation for the out-of-doors? ..... 93.5% answered Yes.

Did you gain educationally, broadening your learning? ..... 100% answered Yes.

Parents commented as follows on questionnaires provided.

" Our daughter was most enthusiastic about the entire experience."

" The exchange of knowledge and science experiences with a peer group of students from all over the valley", seemed most important to one parent.

" Her interest in biology changed from very little interest to a desire to major in biology."

High School Biology teachers who attended the Environmental Teaching Center with the students commented as follows:

> " The Program was very successful and the learning experiences the students were exposed to were unbelievable."
>
> " The Program was well planned and operated very smoothly. Working with small groups in the field was an excellent learning experience."
>
> " I gained considerable from this experience in the field and plan to use the inquiry technique more effectively in my teaching."

Admittedly the preceding questionnaire evidence lacks any semblance of quantifiable objectivity which statistically significant data could provide. However, the positive supportive nature of the responses cannot be ignored.

This cooperative program which provides ArizonaState University students an opportunity to teach Phoenix Union High School biology students in the field has operated successfully for three years.

In November 1970, Arizona State University submitted a proposal through the U.S. Office of Education, Bureau of Educational Personnel Development, for an Environmental Education Teach-In involving the four western states of Hawaii, California, Nevada and Arizona. The proposal was written by a four member committee composed of the members of the instructional team responsible for the biology methods class, Norbert J. Konzal, Leon Jordan, Dr. Kenneth V. Pike, and also included Dr. Ernest E. Snyder, Professor of Science Education at Arizona State University. The proposal recognized several principles which had been clarified from the previous years of providing outdoor education teaching experiences to Arizona State University students. These principles seem to apply regardless of grade level and were used as a basis for the Teach-In program. The principles are listed:

1. Whether elementary or secondary education majors, college students need actual directed teaching experiences in the outdoors with school children if the outdoor education training is to be productive.

2. Many opportunities for environmental education activities exist on the school grounds or in parks or natural areas within walking distance of the school.

3. Upper grade (elementary and secondary) students can profit from an extended field trip up to five days or longer in an outdoor education center. Such a trip can provide opportunities for students to participate in a planned program of environmental studies designed to develop skills and understanding relating to ecological principles influencing environmental quality.

4. The impact of man upon the environment has reached such proportions that we can no longer afford to train teachers in the art of field tripping merely to collect specimens which usually serve no purpose in elementary or secondary school programs.

The proposal was funded and the Teach-In program conducted May 2-14, 1971. The project brought teams of in-service teachers and trainers of teachers to Arizona to observe, experience and practice this inquiry based approach as used by prospective teachers on elementary and secondary students at the Arizona State University Outdoor Education Center at Camp Tontozona.

During the week of May 3-7, 1971, eight (8), three member teams of adults were invited at project expense to participate in the elementary student phase of the Environmental Teach-In. Participant teams consisted of two teachers from the same elementary school and one college or university instructor who would consult with the two teachers in an effort to implement in the local school program some of the desirable techniques observed from the Teach-In.

Participant teams attended from the following population centers:

Phoenix, Arizona
Tucson, Arizona
Los Angeles, California
San Diego, California
San Francisco, California
Honolulu, Hawaii
Las Vegas, Nevada
Reno, Nevada

For the elementary research phase of the project, two fifth-grade elementary classrooms of preponderantly black students were selected from the Julian School, an inner-city school, of the Roosevelt Elementary School District. Both fifth grade classes were provided an Environments unit an kit of instructional materials, teacher guides, and student work books prepared by the Science Curriculum Improvement Study Project under the direction of Dr. Robert Karplus at the University of California, Berkeley. Each of the two classes used the Environments units at the school. A.S.U. student teachers observed and aided classroom teachers with the school program.

For the research study, one of the fifth grade classes remained at the school as a control, and the other class participated in the instructional program at the A.S.U. Environmental Education Center, May 3-7, under the supervision of (5) prospective elementary teachers from Arizona State University. Both classes were administered a pre- and post-test designed to determine attitudinal changes toward certain conceptual terms or statements selected from the S.C.I.S. (Science Curriculum Improvement Study) unit. The testing instrument developed for this study was adapted from the semantic differential technique originated by C.E. Osgood.[1] In our adaptation, the subject was asked to judge a concept by assigning a number on a five point scale against a pair of bi-polar adjectives such as:

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1 Osgood, C.E., Suci, G. . and Tannenbaum, P.H., The Measurement of Meaning. Urbana: University of Illinois Press, 1957.

D. Predator

Interesting	_ _ _ _ _	Not Interesting
Bad	_ _ _ _ _	Good
Needed	_ _ _ _ _	Not Needed
Valuable	_ _ _ _ _	Worthless
Harmful	_ _ _ _ _	Helpful
Unfair	_ _ _ _ _	Fair
Active	_ _ _ _ _	Passive
Unfavorable	_ _ _ _ _	Favorable
Exists	_ _ _ _ _	Does not Exist
Cruel	_ _ _ _ _	Kind

The concepts students were asked to rate are listed:

A. Environmental Community; B. Populations; C. Range; D. Predator; E. Some living things need non-living things; F. Environmental Change; G. Optimum Range; H. Some living things need other living things.

During the second week of the Teach-In, May 10-14, 1971, the program was repeated with the following changes. Participating teams were invited from the same centers of population but representing the secondary level of teaching and teacher preparation. High School biology classes from Phoenix Union High School were invited to participate,and the A.S.U. students were secondary level biological science majors. Both groups of students received environmental instruction at the high school. The control group continued their biology studies at the school while the experimental group traveled to the Environmental Center to engage in a week of inquiry oriented field studies under the supervision of five (5) high school biology student teachers from Arizona State University. Both groups of high school students responded to the following concepts on pre- and post-tests:

A. Environmental Community; B. Environmental Change; C. Population; D. Some living things need other living things; E. Environmental Quality; F. Energy Flow; G. Some living things need non-living things; H. Ecology; I. Pollution; and J. Interdependency.

Each concept was rated on a five point scale against the same list of ten (10) bi-polar adjectives used on the elementary tests listed on page 12.

Adult participants, both elementary and secondary, were given a similar attitudinal pre- and post- test based upon the semantic differential technique. They were asked to respond to the concepts as listed:

A. Inquiry Teaching; B. Environmental Education; C. Interdependence; D. Field Studies; E. Environmental Quality; F. Energy Flow; G. Ecology; H. Interdisciplinary; I. Pollution; and J. Lecture.

Each concept was rated on a five point scale against a list of ten bi-polar adjectives according to the following example.

A. Inquiry Teaching

Active	_ _ _ _ _	Passive
Hazy	_ _ _ _ _	Clear
Unnecessary	_ _ _ _ _	Necessary
Helpful	_ _ _ _ _	Harmful
Worthless	_ _ _ _ _	Valuable
Honest	_ _ _ _ _	Dishonest
Ugly	_ _ _ _ _	Beautiful
Pleasant	_ _ _ _ _	Unpleasant
Dirty	_ _ _ _ _	Clean
Delicate	_ _ _ _ _	Rugged

In addition to the attitudinal test, participants were asked to respond to an evaluative questionnaire. Following is a summary of comments made by elementary level Teach-In participants. A total of twenty questionnaires was received from the group of twenty four.

EVALUATIVE QUESTIONNAIRE

Elementary Participants of 1971 Environmental Education Teach-In

1. What needs to be done to implement environmental education in your local situation?

   a. In-service teacher training needs to be provided for district teachers (35%).

   b. Administrators need to be convinced of the need for environmental studies (40%).

   c. Money must be made available either through local, state, and/or federal funds (35%).

   d. Cooperative efforts with elementary, secondary, and college level people must be established (35%).

   e. The public must be made aware of the need for environmental studies (25%).

2. Do you plan any E.E. approaches in your own teaching situation? If so, what?

   a. Provide more field experiences for classroom students (40%).

   b. Develop a local program for elementary students on a district level (30%).

   c. Provide a pre-service program for college education majors (20%).

3. What were the strengths of the Teach-In?

   a. Contacts with participants and consultants (65%).

   b. The use of students for practicing new techniques and methods (40%).

   c. The demonstration of methods and techniques presented (15%).

   d. The abilities of the student teachers (25%).

4. If the Teach-In were to be repeated, what suggestions for improvement do you have?

   a. Better communication between staff and participants before the teach-in sessions begin (20%).

   b. Use an interdisciplinary approach to environmental education (10%).

One Arizona State University elementary education major student teacher commented about the experience as follows:

> " The children thought it was worthwhile --- I asked them if they would do it again or recommend it for others. They were sure that they would. For changes they suggested more time to explore without so many questions and more time in the lab.
>
> Changes in the childrens' behavior.
>
> The most easily remarked change was their loss of fears --- of climbing, of insects, of storms --- which yielded to curiosity about storms, interest in insects and enthusiasm for climbing.
>
> On a social level they were aware that not everyone finds the same things interesting and they accepted this. Knowledge and common interests created bonds between people and an easy basis for exchanging ideas and making friends.

They didn't exchange and discuss very much on Monday, but they enjoyed it by Friday. The child who had been a loner became a member of three different small groups and even got around to smiling and talking to strangers. The color barrier which the children had raised was down by the end of the second day. They accepted those in authority without resentment or fear. The girls got an expanded view of themselves and what they could do now and in the future.

As budding young scientists they learned to recognize animal tracks and trails,and it awakened an interest in animal habits.' Ted didn't tell anyone where the squirrels had hidden their winter food supply. They decided that things weren't always what they seemed, i.e., The water appeared to be boiling, but it was cold; the twig could move -- it was a larva --'not a worm, a larva. I looked it up, but I can't decide which kind,' so three girls told me. By the end of the week a group of children who had picked up a frog and seen it injured as it leapt from someone's hands informed me that they were really the intruders in that environment. Some of them suggested returning their collected specimens, and as they picked a few leaves for tea, they became aware that they must not destroy the plants or there would be none for next year. Thursday they cleaned up debris that they had dropped earlier in the week without being asked while we were hunting the stream bed for tracks and things.

It was on Thursday that I realized that they were generally paying more attention to detail --- beginning to classify likenesses and differences in the plants and rocks and environments around them, noticing the differences in leaves and bark, and configuration in the land and wondering. For instance, 'Where does the water come from here? (at Natural Bridge) Oh, I see it must .....,' and 'What made that hole over in the field? I guess a lot of things could do it, I think its from ....' ."

The fifth graders comments in answer to the question, " How would you improve the field trip? " are typified by the following:

" I think it should be left just the way it is. "

" There were too many Daddy Long Legs in the bathrooms. The rest of the field trip was O.K. "

" I couldn't find anything wrong with it. It was the way I like it. It was beautiful. Say 'hi' to everybody. Tell them I miss them. "

Secondary level student teachers from Arizona State University had these reactions following their participation in the Teach-In experience.

> " On the whole I would say that the project was a success if for no other reason than that the students began to realize that man shares the environment with a vast collection of other organisms, which all provide an important contribution in nature ..... During this week the students had the opportunity to see how disrupting the environment, by either man-made or natural means, could actually change the habitats, predator-prey relationships, ecological niches, and need for adaptation. They were also able to observe a variety of interrelationships among plant-plant, animal-plant, animan-animal, soil-plant-animal, and other factors of the environment. These observations indicated the natural flow and interchange of energy as well as the food web, and man's dependence on a balance in nature. To be sure the students comprehended these concepts in varying degrees. Many of the students were quite impressed, a few remained almost oblivious to the concepts but some perceived them very intensely. Several times I was gratified by comments made by the students which indicated how much they were comprehending. "

> " After four days practically every single one of these high school stuaents had found an area of interest and was researching it, not because they were forced to do so but because they were interested and having a good time learning. "

Following is a summary of comments made most often by Secondary level Teach-In Participants. A total of twenty-three questionnaires were received from the group of twenty-four.

EVALUATIVE QUESTIONNAIRE

Secondary Participants of 1971 Environmental Education Teach-In

1. What needs to be done to implement environmental education in your local situation?

   a. Administrators of local school districts need to be convinced of the need for environmental education studies (18%).

   b. In-service workshops need to be provided on a state and local level (35%).

c. Curricular areas need to be more fully integrated to provide a total educational experience (26%).

d. Money must be made available either through local, state or federal funds (30%).

e. Cooperative efforts with elementary, secondary, and college level people must be established (18%).

2. Do you plan any E.E. approaches in your own teaching situation? If so, what?

a. Provide more field experiences for classroom students (39%).

b. Develop or revise a program for high school students (26%).

c. Provide a pre-service program for college students in education (17%).

3. What were the strengths of the Teach-In?

a. The demonstration of methods and techniques presented (48%).

b. Contacts made with other participants and consultants (50%).

c. The use of students for practicing the methods and techniques discussed (50%).

d. The abilities of the student teachers (39%).

4. If the Teach-In were to be repeated, what suggestions for improvement do you have?

a. Allow more time to work with the students in the field and the lab (39%).

b. Allow the participants to practice methods on the other participants before going to the students (12%).

c. Provide more guest lecturers (12%).

The Environmental Education Teach-In was highly successful judging from the favorable response of all parties concerned. Whether or not attitudinal changes were affected as measured by the semantic differential pre- and post-tests remains to be determined and will be reported when statistical treatment of the data has been completed. For now the regional

nature of the Teach-In, as it involved in-service teachers, college trainers of teachers, university prospective teachers, working with elementary and secondary level students in an outdoor environment seems to provide a pattern for enhancing environmental education as an integral aspect of public education.

To teachers interested in providing students an introduction to science as an inquiry oriented endeavor, we heartily recommend use of the environment outside of the classroom as a primary source of study. One work of caution, however, the outdoor environment does not lend itself to the lecture method of teaching - too many inquiry oriented distractions !

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